

# The anti-aircraft gun and missile system "Tunguska"

*Vladimir Korovin*

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*Operating experience of the first anti-aircraft missile systems, gained more by the end of the 1950s., Testified that almost all of them turned out to be unsuitable for an effective fight against low-flying targets. The first experiments to overcome air defense systems aircraft flying at low altitude, have shown impressive results. For example, an airplane flying at a speed of 720 km / h at an altitude of 400 meters, could be detected by ground-based radar at a distance of 40 km. After that, the disposal of air defense to prepare to repel the attack was a little more than 3 minutes. In turn, the aircraft that could fly at transonic speeds at altitudes of 50-100 m, were found at a distance of 5-10 km, and from the moment of their discovery to fly over the defending object is just 15-25 seconds. During this time, air defense required to calculate the parameters of target motion, to implement its acquisition and tracking, to determine the degree of threat, the possibility of fire, and, ultimately, of launching missiles. To fight against such an enemy required qualitatively different SAM tools.*

Work on their creation began in the late 1950s. However, the rapid success was not achieved nikomu- no Americans ("Mauler") or the British ("Tiger Cat") or the French ("Cactus") ... The complexity of the task was at the limit of the technical possibilities of the time. As a result, during the second half of the 1960s. to replace the majority of programs focus on the development of low-altitude air defense

missile systems, came more pragmatic, based on the use of automatic anti-aircraft guns.

Of particular interest in this area arose after the Soviet Union was adopted by the ZSU-23-4 "Shilka" (head developer - OKB-40 Mytishchi machine-building plant), equipped with four 23-mm cannon. In the mid-1960s. combat capabilities "Shilka" began intensively promoted to the military leaders of the Warsaw Pact, as well as several countries in the Middle East, Africa and Asia. The guest is usually reported that in action were shown only the first production samples ZSU and is working on its next, more efficient alternatives.

Indeed, it became the firstborn in their class, "Shilka" had a number of shortcomings. So, its radar 1RL33 have limited search capabilities - in the sector of  $15-40^\circ$  in azimuth with a simultaneous change in the elevation angle within  $7^\circ$  of the set direction of the axis of the antenna. The high efficiency of target detection is achieved only if the prior target designation, and in its absence does not exceed 20%.

Leading role began in 1968-1969. work on the modernization of the "Shilka" design bureau was assigned Ulyanovsk Machine Building Plant, which already had the experience of creating complex radiopribornogo to control the fire anti-aircraft "Yenisei". There for "Shilka" Radar processed, refined fighting machine. As a result, we are increasing the likelihood of capturing the target radar and accurate firing. During the 1970-1971 biennium. on Donguz test site, at the site in Kubinka and Turkmenistan held Polygon-service testing of the new version of "Shilka", which showed a marked increase in its characteristics.

One of the first international response "Shilka" was the six-"Volcano", which began in 1970 as a rapid-fit anti-aircraft guns. However, customers have little enthusiasm zenith "Volcano" has not caused due to the limited range, accuracy and efficiency of fire. Slightly better results in the years shown and other artillery units, specially designed for the fight against low-altitude targets.

As a result, overseas for some time the best solution to combat such objectives were recognized, portable SAM systems, as well as complexes that used aircraft missiles adapted for launch from ground installations. Nevertheless, solid "gaps" in the American and European low-altitude air defense systems is still preserved. After the beginning of the 1970s. It brought with it not only the appearance of supersonic passenger aircraft and Airbus. During these years, warplanes confidently mastered the small and extremely low altitudes, where they flew at subsonic and supersonic speeds, using the latest means of electronic countermeasures. Is becoming a reality and creating stormtroopers book can is getting 23-mm shells. At the same time in combat in Vietnam and the Middle East have demonstrated high efficiency and combat helicopters armed with anti-tank missiles. Their tactics usually consisted in taking a position, nestled in the folds of

the terrain, and "bouncing" on the height of 15-25 m with the launch in a few seconds a series of missiles. This tactic has led to a sharp decrease in the detection range of aerial targets like air defenses and reduce the time to prepare the data to open fire.



*ZSU- 23-4 "Shilka".*

And again, as in the decade before that, it is concluded that for effective struggle with the air enemy air defense systems are needed that are based on the integrated use of reconnaissance and destruction, with a high degree of automation of the processes for obtaining and processing information, management and target allocation. In turn, their creation was based on the use of a systematic approach, the

main aim of which was to achieve optimal or rational (adequate, acceptable) values of quality complex technical system as a whole rather than the individual elements.

For the first time such an approach in relation to the establishment of air defense has been applied in the 1963- 1964 biennium. when the NII-3 with a number of research organizations "Bean" staged NTC Grau, the results of which later served as the rationale and scientific basis for the creation of a second-generation weapons systems of air defense troops of the Ground Forces.

The findings made by the then highlighted the key trends in the development of air attack: the preservation of the strength of the aircraft; the unification of their type; instrumentation creation of active and passive jamming; combat operations primarily tactical aircraft at low altitudes; the appearance of combat helicopters. This analysis showed that none of the air defense systems, the available or ready for adoption by the Soviet Army troops, in full capacity to deal with such objectives do not possess.

One of the results of implementation of R & D "Bean" was the assessment of the possible long-term performance of air defense systems for the tank and motorized rifle regiments, capable of acting as a part of progressive forces and repel the attacks of the enemy's land. It appeared in the form of a conglomerate, equipped with more powerful compared to the "Shilka" cannon armament and anti-aircraft guided missiles "Strela-1" and radiopribornym equipment, providing shooting guns and missile guidance.

At the end of 1960. on Donguz test site SRI-3 Grau, TSNIITOKHMASH MOS supported by Grau started to prepare a new TTT regimental air defense systems.

The basis of this work was on the experience of the first years of operation, "Shilka", which showed that the anti-aircraft artillery, despite the high efficiency and good fighting qualities of the first taken into service short-range air defense system, still retains the rights to its rightful place in the arsenal of air defense systems, and It is also able to effectively engage manpower and armored vehicles of the enemy. Peculiar to the automatic gun shortcomings (small areas of effective targets and fire missiles poor power necessary to defeat the purpose of the new types) were considered surmountable by increasing their caliber and 30 mm. According to calculations, it is possible to reduce 2-3 times required to hit a target number of hits, increase efficiency destroy ground targets while maintaining the same rate of fire. At the same time, a further increase in the caliber are not allowed to provide a rate of fire.

In general, these requirements provided that the new complex should be in constant readiness for the evaluation of air situation, to detect air targets while driving, have a fast response time, high probability of target destruction, as well as being highly mobile and aerotransportabelnym, have a low cost and relatively easy to maintain.



AG Shipunov.

The TTZ formed wondered requirements range, height and combat effectiveness of the shooting, which twice the characteristics of the "Shilka" and the response time (the time from the release of information on the purpose of the detection target of the means of support to the operator presses the button "start") was not 10 s.

Soon, according to the Ministry of Defence received from the TTP, in the Tula Instrument Design Bureau started the elaboration of the type ZSU "Shilka", equipped with two 30-mm guns. Work has been assigned the code "Tunguska" and the chief designer of ZSU was appointed head of the PCU AG Shipunov. Monitoring the progress of work carried out in 1839 VI Ministry of Defence, headed by IP Beschastnykh, and since 1975 - VI Basov.

Arkady G. Shipunov recalled: *"We are in the PCU started thinking about this job, even doing improvement" Shilka "when taking measures to reduce errors in aiming, by studying the possibility of increasing the power of its missiles. In doing so, we come to understand the need for the transition to the use of separated radars to be installed computing devices and 30-mm guns. And, to some extent, based on our work, customers have started to prepare for the formulation of the problem to a new, revised edition of "Shilka", which was called "Tunguska". With the prepared documents they came to the defense industry, there began to be measured, to wonder - what issue the company in its elaboration. Have learned well the lessons of "Shilka" mytischintsy immediately abandoned the work, abandoned it and Ministry of Radio Industry, who at the time was a monopolist in such cases. As a result, it identified the Ministry of the Defense, to Zverev. Sergey phoned all his chief designers and stopped us, because, as he told me on the phone: "Everything had to give up."* For a while, the pace of work has remained low since the CBI does not yet have a sufficient amount of experimental data on the tests create here and are best suited for the task 30mm automatic cannon AO-17 and AO-18. Severe experimental verification required for issues related to other elements of the installation - radiopribornymi complexes sights, shells and so on. On the whole, the very formulation of the new tasks caused a considerable number of questions and doubts. Ultimately, KBP assessment experts showed that a real breakthrough in increasing the effectiveness of the military perspective of short-range air defense systems can only be achieved with the rational combination of cannon armament rocket.

This idea was based on the similarity of control systems by artillery and rocket weapons, the possibility of using the same information systems for the guidance of guns and missiles. At the same time the rocket had to fire air targets flying across the affected area, and gun - firing at targets moving at extremely low altitudes and

suddenly appear out of the shelters. In addition, the gun armament, due to the low cost of its ammunition could be used to defeat the cheap and mass targets such as remotely piloted vehicles. Similarly, it was justified and the requirements for radar detection, which is used to provide high efficiency of shooting in any direction.

Meanwhile, well-oiled machine of decision-making continued to gain momentum. June 8, 1970 on the initiative of Grau was accepted by the Central Committee of the CPSU and the USSR Council of Ministers on holding №427-151 PCU in cooperation with several other organizations of defense industry research and experimental studies to determine the feasibility of creating a new 30-mm self-propelled anti-aircraft installation.



VI Abaulin.



RJ Purtsen.



PS Caumont



CM. Berezin.

AG Shipunov recalled: *"Faced with a fait accompli, I started to protest. Soon I was invited to a meeting at the MIC, which have listened carefully to the views of the enterprise. I explained that we needed to forestall a situation in which previously appeared developers "Shilka". Of course, we will find new solutions that will do better, but because of the limitations that we will ask the use of guns as the primary means of fire, we will not go. We obtain a range of four kilometers, height - three, but still it will be "the same soup, only thinner." In the given work we missing a qualitative leap that allowed us to reach the creation of a complex of new generation. So I suggested that we were allowed to do no gun and missile-gun system. Of course, I was accompanied by my statement showing numerous charts, graphs, tables, we have prepared the company.*

*My statement has caused some skepticism, particularly among radioproma rightly saw in us a potential competitor. On the contrary, the head of the military industrial complex Leonid Vasilyevich Smirnov our offer aroused considerable interest, as the leaders of the development, as a rule, sought to facilitate their tasks. And permits to work through rocket-gun version, which I wanted, was obtained.*

*Initially, the company developing the project of rocket and gun "Tunguska" headed by Head of the PCU Valentin Abaulin, Ph.D., known also by the fact that he was the champion of the USSR in Russian checkers.*

*Work on the "Tunguska" significantly different from what we've previously engaged.*

*It was not only the new, but also much more complex task for our company. We needed to create a new unit, which engaged in the implementation of the enormous amount of work with appropriate specificity. The office we have organized on the basis of the department, to create war machines, and became its first head Rudolf Yanovich Purtsen. Under his leadership, a lot of it was worked out arrangements "Tunguska", until finally they came to a variant that satisfied everyone. This arrangement, with side-mounted cannons and missiles, and looked nice and compact, it is well linked to all major decisions.*

*Soon to the aid it has been directed Purtsenu Peter S. Caumont, who became deputy chief of department. As a result, the initial stage of work on the "Tunguska" main leadership was behind me, and Purtsenom Komonovym, as well as heads of departments Vladimir Grigoryevich Vnukovo, Victor K. Korostiev, Alexander D. Markovic and Vladimir Puchkov Kuznetsov. We then created another division, which do computer technology, software and mathematical software. His chief was Alexander Lazarevic Krichevsky. "*

To meet the challenges of the external design department VI Abaulina was organized by a specialized laboratory, which later led Berezin Sergei Mikhailovich, the son of the outstanding arms designer ME Berezin, grew up in a large multi-department. CM. Berezin actually voluntarily assumed the analysis of the conditions of future combat use of "Tunguska", the typical choice of accommodation facilities of weapons and combat situations, military and economic analysis, the formation of rational facial features of ammunition and guns unified system, forecasting of terms of their turnover. In the process of solving these urgent problems have begun to crystallize and practiced basic theoretical principles of applied science the effectiveness of various types of weapons that eventually became recognized as interbranch canons. Raising such a promising scientific "virgin" SM Berezin wisely used this exceptionally favorable conditions for increasing the level of scientific training of personnel of the enterprise, showing by example how to compensate the young age of the collective opinion of authoritative scholars of his employees.

As a result, in a prepared to top 1973 draft design with the main gun "Tunguska" it was proposed and had no unique project of its rocket-gun version. This complex receives the maximum autonomous: one military machine were combined radar and optical means of detection, tracking and fire control, cannon (basic) and rocket (additional) weapons. The use in the "Tunguska" a combination of radar and optical means can count on efficient work against targets flying at an altitude of 10 meters, the high noise immunity of the complex.

Firepower "Tunguska" were to become two 30-mm machine with liquid cooling system and ammunition rounds, and eight launchers with ammunition and guide missiles in launching transporting containers. The range of the guns was to reach 3.5 km, the missiles - to 8 km. In fact, missile and gun "Tunguska" was to become the world's first self-propelled air defense dvuheshelonny short range.

However, by this time in the backlog it was a powerful and easy two-barrel gun design VP Gryazev. Rocket had only in the plan - bikalibernaya, with the starting motor of a large diameter and small diameter stage march. According to preliminary estimates, the starter motor can disperse the rocket up to 900 m / s and undock, then step march proceeded on the decline. At the same time high ballistic performance sustainer stage allowed her to fly in the atmosphere with minimal loss of speed. As a result, an 8-km range, it was the speed of the order of 450 m / s and



feature overload, sufficient to defeat maneuvering air target. Management missile was produced by radio, formed the equipment installed in the ZSU. In turn, on-board equipment is located in the march stairs, takes a relatively small amount, allowing to equip a missile warhead, the mass of which was almost half the mass of marching steps.

Give a word AG Shipunovo. *"The development of missiles for the" Tunguska "we decided not to give up in the unit where they worked ATGM developers. For this problem required other technical solutions, and to find them we created the department led by Vladimir Markovic Kuznetsova, who became the chief designer of the rocket. Young but already experienced engineer a rocket sensitive to new ideas and capable of generating their own. It is worth noting that in this work we have formed working team with a lot of creative young people.*

*At first, the main task we have seen to determine the missile select its parameters, layout. Of course, in the enterprise, this work was not without controversy, considered various projects. I tried to behave in these works as soon as possible cautious. But the opinion, which was to get the missile, I had already formed and, whenever possible, pushing designers to version with detachable starter motor and the engine is not equipped with a small-caliber marching step - to the so-called bikalibernoy scheme. This missile greatly deviated from tradition, primarily, due to lack of main engine, the presence of which the anti-aircraft missiles was considered mandatory. Canons existed required a fully powered trajectory as braking rocket sustainer stage require additional mining angular acceleration. And we are going to use only the start of the engine, most of the work to restore shifted to the passive station. But, as in doing so we halved the caliber of marching steps, then significantly decreased and the braking force. A flight path with respect to time, could determine the effective forces and moments that might be compensated for in the programs guidance. Although at first no one in particular these figures did not believe, but it was a reality. In the end, on this version, we all came together and the company. Of course, today clearly shows that if we could not reach the ideal in terms of choice of optimum parameters and design solutions. Still, we found the scheme missile contained a fresh and very promising idea, allowing to achieve excellent results. "*



VM Kuznetsov



*H.E. Schornikov*

The proposed layout for the new SAM does not have analogues among anti-aircraft short-range missiles, but because she immediately bought not only allies, but also opponents, and among the very famous designers.

*As recalled SM Berezin, ".After development in our department offers to build a rocket shape with detachable motor and a significant difference in caliber we had no time to go to the NII-3. Explain the benefits of our solutions, to establish contacts with the department that oversaw the zenith direction and led the military-economic analysis. In general, if we had done a lot of work: the technical council held, the results of protection. Of course, then we are still quite poorly versed in the subject, so all the calculations were given difficult. "*

However, Tula was not a novelty to go against conventional wisdom. All the more so with each passing month bikalibernaya layout missile demonstrated its new and new advantages. Thus, the lack of engine sustainer stage excluded smoke boresight target at the most critical parts of the interception, guaranteeing reliable and accurate missile guidance, allowed to reduce its weight and dimensions, simplifying the layout of the onboard equipment and military equipment. It also helped to launch and implement passive aerodynamic damping in flight, which was provided by the correction of the control loop by sending appropriate commands to the rocket from the computer system of the complex. In general, the use of bikalibernoy scheme enabled almost halve the weight of the rocket in comparison with the single-stage missiles, which have a similar zone of destruction, and get a high flight ballistic characteristics.

Characteristics adopted for the "Tunguska" double-barreled 30-mm anti-aircraft machine 2A38 fully meet the expected level of excellence of the installation. If the initial velocity of projectiles 960- 980 m / s area of his defeat was 4 km distance and 3 km height. The machine can work at angles of elevation from -9 to + 85 °, and the rate of fire was 4060-4810 rds. / Min. This ammunition shells was in general a cartridge tape, consisting of units of ammunition, missiles have high-explosive-incendiary (3UOF8) and fragmentation-tracer action (3UOR6) in a ratio of 1: 4. The machine was equipped with a single feeder and a firing mechanism

percussion, which in turn served left and right trunks. The machine retains its performance over a temperature range of  $\pm 50^{\circ}\text{C}$ . Positive temperatures cooled with water cannons trunks, while negative - anti-freeze.

Design solutions used to create 2A38, to ensure its safe operation in all conditions: in rain and icing, when shooting without cleaning and lubrication for a few days. This vitality of each barrel was no less than 8,000 shots in the shooting mode 100 shots on the machine, followed by cooling.

AG Shipunov said: *"In the initial stages of the machine we have been given, that the accuracy of its guidance should be three times better than the" Shilka ". However, even such requirements do not ensure that the objectives on the borders of the affected areas will be hit first. Of course, we could not so easy to agree with this and appealed to developers to drive guidance in the carpet. But there is no quick solutions could not be found, and we took up the case in the traditional way, hand in solving this problem at home. We soon found out that the pointing accuracy is limited by the control system used drives. I proposed to tackle this problem our leading expert Yevgeny Yefimovich Shornikova, and he soon found an interesting option. We quickly made the experimental sample, sent it to the landfill, and it turned out all right. Then we talked again with kovrovchanami, and they took us to a new job. As a result, we have ensured that the "Tunguska", each covering all purpose anywhere in the affected area. Even group errors do not exceed the value of the ellipse of dispersion.*

*When we came to the defense of conceptual design of gun-missile "Tunguska" in Grau, stood among the crowd murmuring easy. All at first sight it was more or less clear what will be a fighting machine, radar, rapid-30-mm cannon. But our bikalibernaya missile was a complete revelation to all. Of course, not everything in it looked elegant, something we have done with excess inventory. However, I announced on the protection characteristics as distracting from the overall series, which forced to think seriously. Indeed, at the same weight as that of the British "Rapier" and "Arrows-10", we have one and a half times the range. The British, for obvious reasons, to join us in the discussion failed, and attended the Protection Project Alexander Nudelman Emmanuilovich when performances began, he stood up and said that such missiles can not be. Naturally, all eyes turned to me. Chaired the protection of the general, after these words, asked me:*

*- Arcady Georgievich, how do you feel about this conclusion? Do you agree with him?*

*And I'm still under the impression that only made me a report with some triumph in his voice said:*

*- Treat as the highest praise!*

*This was followed by attending restrained smile, murmur, but no one to enter into the debate did not.*

*After some time, his negative conclusions about our missiles sent to Grau and other designers-missile troops. Then I could not take off to meet in detail, but in general I was told about them. Of course, it is unpleasant, when expressed doubt our colleagues, but I could oppose them? Only by successfully flying a rocket. "*

However, despite the support received NII-3 and Grau, the time for a final decision on the use in the "Tunguska" rockets has not yet come. In 1973 he was accepted by the Central Committee of the CPSU and the USSR Council of Ministers on the development of the technical design and prototype anti-infantry installation "Tunguska". In the same year the decision of the Council of Ministers was set research "Dam", whose main goal was to find ways to protect ground troops and, first of all, attacking tanks and armored vehicles from the blows of combat helicopters.



*30-mm automatic cannon 2A38.*

*According to the memoirs AG Shipunova, "the release of preliminary design for the" Tunguska ", where we offered as an option to install an additional missile, significantly increased the excitement in the camp of our competitors from the radio. They immediately began to fuss, we began to put forward their proposals. In general, it began the traditional struggle of supporters and opponents. At that moment I seriously began to fear that our initiative will close the job, especially since the Minister of Radio Valery Kalmykov and our Minister Sergey Zverev were neighbors to testify and can discuss informally the most sensitive issues. But luck was still on our side.*

*One meeting was held in the MIC for a narrow circle of persons who were related to the development of military air defense. Kalmykov began to speak first to the fact that we began to persuade to abandon the chosen path:*

*- Do you understand what anti-aircraft missile, - he said. - It's not ATGM!*

*Gradually, he began to make more and more, began to talk about that soon will be hit aerial targets with laser beams and that this work is already at the exit. However, to attend the meeting Zvereva fiery speech Kalmykov has not made*

*much of an impression. And when it was his turn to speak, he went up to this point in the business:*

*- Tula residents want to do the rocket as additional weapons complex. Let them do, they have to do everything possible. Such an approach can only be welcomed because as a result the country will receive weapons, which nobody else there.*

*Actually, after the meeting, the development of rocket us finally start zatverzhdatsya. We had tremendous help while in the Grau and his head NII-3, where we supported the leading experts working in the management of air defense - II Zlatomrezhev and SA Transplant ".*

While in Moscow, there were discussions on Donguz test site (Head poligona- OK Dmitriev) began testing in the framework of the research project "Dam". The role of the head artist of this work was assigned to NII-3 (supervisor work - SI Petukhov).

On the training ground was prepared and conducted by experienced scientists (Head teachings - Gatsolaev VA) with firing on helicopters target of various weapons (tank, anti-tank, anti-aircraft, including the latest SAM "Osa") that were in service of the Land Forces. The results indicated that the teachings of the proposal and the PCU Grau on the establishment of missile-gun complex short-range is correct and timely. As a result, in 1975 the Ministry of Defense to the TTT Grau "Tunguska", equipped with artillery and missile weapons, were finally approved. This was attended by military engineers Grau EM Trubnikov, VY Wojciechowski, NP Bryzgalov, VM Shkuratovsky, Research Institute of BC-3 Schukin VI Barabanov, AD Turyanov.

Having received a positive opinion, the PCU and groups allied enterprises under the control of the customers started to develop technical documentation and then to the production of the first sample ZSU. Completion of its assembly, which was conducted in the experimental production of the PCU, scheduled for 1976 Two prototypes of "Tunguska", intended for preliminary and state tests, produced at the Ulyanovsk Mechanical Plant, which was identified as a future manufacturer of serial combat vehicles.

However, the acceleration in the works again followed, this time - for organizational and financial reasons. After all, the other side of the expected increase in efficiency "Tunguska" was a significant complication, need the involvement of the most powerful co-operation, which was to include about a hundred companies from 13 ministries. And quite naturally increases the cost of developing its expediency has given rise to serious doubts in the Ministry of Defence. They are even more intensified after the same 1975 has been adopted a modernized version of the self-propelled SAM "Osa". The new complex "OSA-AK" had a higher performance in range and altitude hit targets than it was planned

for "Tunguska". In addition, its developers are not resting on our laurels: in November 1975, they embarked on another modernization "Osa", which was to acquire the ability to fight against helicopter gunships. In the same year work began and over the short-range air defense missile system of a new generation of "Tor." As a result, it was decided to cease financing the "Tunguska" ...



*PN Kuleshov.*

However, supporters of the "Tunguska" (and among them were the Deputy Minister of Defense Industry Lev Sergeyevich Mochalin Grau and Chief Artillery Marshal Pavel Kuleshov) did not lay down arms.

*PN Kuleshov recalled: "I happened to be in the thick of the processes associated with this work. In terms of air defense customers had to do and prove extremely difficult choice between the desire to achieve maximum performance and cost developments between the desire for unification and the creation of specialized funds. And I did everything to implement its main business principles. I sell them with a view to seek to achieve the highest performance of the new weapon. For this, I, as in the war years, dispersed force, thus avoiding manifestations of human error in the development, contributed to the establishment and full development of design teams, which turn out the latest technology and where grew up and out "into the world" talented specialists and managers .. . Of course, in these years with the decisions that I made and defended, while in office, was not everyone agrees. There were also insults and perennial quarrels, sometimes developed into heated verbal battles at the highest levels. But, ultimately, in most of its proposals, I found support for the leadership of the Defence Ministry and the country. And one of the developments, which required me to best effort was "Tunguska".*













To resume work on the "Tunguska" It took almost two years of persistent efforts, together with PN Kuleshov, LS Mochalin and AG Shipunov taken the chief head of NII-3 Alexey Volzhin. Their main argument in this fight was that the "Tunguska" will not only have the highest efficiency of target destruction, but also the minimum response time - three times less than what SAM "Osa-AK." This characteristic, as the analysis of combat operations in Vietnam and the Middle East, has become one of the key in the fight against air threats of the new generation. And the opportunity to continue the work on the "Tunguska" will soon present.

According to the memoirs LS Mochalina, *"podgotovka a new exit on the scene" Tunguska "began after us in the ministry received a signal from the exercises held in the Baltic States. These exercises attended just two senior military commander - IE Petrov and VF Margelov. As it turned out, they witnessed how during the exercise helicopter gunships were able to frustrate almost all offensive operations.*

*At the same time attacking units were armed with Zu-23 and "Shilka", which has not brought the fire helicopters any problems. Conclusion Commander was quite alarming - bad thing, it is necessary to do something. At that time already started to develop the complex "Tor", which fully supported the DF Ustinov. In contrast to the "Tunguska", he did not have guns. However, zaiknuvshis was a continuation of*

*the work on the "Tunguska" I received from Ustinov's denial of the most unpleasant form. And then, using the range of its relations, a new attempt to promote "Tunguska" has taken Shipunov. It turned out that after the exercise of supporters at his development significantly increased. As a result, we were able to quickly prepare a draft decision MIC, the Council of Ministers has approved them Leonid Smirnov.*

*Of course, our work has not gone unnoticed. Soon I was summoned by the chief of the defense department TSKI.D. Serbia and in the most severe form of saying, "Where are you getting! You heard what I said Ustinov! "In general, chastised me. But this time we do not lose heart. And once we learned that Ustinov had gone on a long trip, and it was to replace the Chief of General Staff Nikolai Ogarkov, refers to the "Tunguska" more favorably. We have dramatically accelerated the pace of collecting the necessary visas and signatures, signed the documents in the General Staff, the Deputy Minister has approved the work VM Shabanov. As a result, the decision to continue work on the "Tunguska" left unsigned Ustinova, and we all - participants of "collusion" - got him into disgrace and, above all, Shipunov. One, he knows what he has gone through in those months. Nevertheless, the work has proceeded very well. "*



*AG Shipunov, LS Mochalin and AN Volzhin.*

The first "Tunguska" moved on Donguz test site in 1976. Traditionally, the CBI was filed so - the product is experiencing at the site one who develops. In the process of preparation for range tests employees of this department had to deal with organizational issues of security, creating at the site of normal living conditions, the organization of transport, delivery of all kinds of goods, preparation techniques and experimentation, evaluation, refinement of test samples, documentation correction.

PS Caumont recalled: "For the test "Tunguska" to the landfill in Donguz were sent three combat vehicles, the crew of each of which was for four people. The total number of Getting Started test teams reached with subcontractors 50 - 60 people, and sometimes up to 80 people and all the members of this no small teams worked

*almost continuously in three shifts, some employees often did not leave the technical positions all day, and worked almost seven days a week. A truly worked selflessly YL Kuzmich, AL Krichevsky, AS Mashkin, EA Meltzer, A.M. Davydov, AA Puchkov, VA Cooks, BC Ovchinnikov, VI Shablovsky and many others. "*

Along with them, we worked and representatives of the customers, employees 1839 EP Ministry of Defense and other military missions. Replacing each other, constantly monitor the progress of work at the site YM Andrianov, AG Golovin, VN Yefimov, MI Humps, PA Trofimov. In some cases, military representatives are not just supervisors and colleagues, and in a sense, and co-authors of the work performed.

Many of the participants in these trials had a chance to be in a state of excitement this business for almost four years. Reached that excess working hours began to complain of the military personnel called to the tests ... This tension did not know at the site since its inception.

As noted by AL Krichevsky, *"during the tests" Tunguska "Arkady G. Shipunov brought at the site rigid order. He pitched professionals are here to group appointed their superiors, and every evening, all the chief report back in a day. This method of management proved to be very productive once it went "like clockwork," began shooting, began to fall. "*

One of the innovations used for the "Tunguska" has become established for her digital information processing system. It had a lot of help PCU professionals and MIET rector Leonid Presnukhin taking over a significant share of work on the docking equipment fighting machine with serial CMC, on the device of input-output. "Mietovtsy" is also proposed to use for the "Tunguska" and the latest digital sensors, which was not yet in production.



*LN Presnukhin.*



VA Barkhotkin.

Experts MIET is not the first time to participate in joint projects with leading developers of new weapons. Already in 1972, for the implementation of the available capacity at the Institute Leo Presnukhin based research teams, working at the Department of "Computer Science" at the Department of MIET and "computing devices" Bauman, has created a research laboratory Defense Ministry. Presnukhin became the supervisor of the lab and its chief - Vyacheslav Barkhotkin. The main tasks of the laboratory is the development of complex systems of computer technology for the newest weapons systems, including armored computing devices, artillery of computing devices, computing devices for self-propelled anti-aircraft and naval systems, control equipment for anti-aircraft and anti-tank missiles.

By 1975, the volume of research that began to perform in college laboratories, grown so much that they came to meet with Minister of Defense Industry SA Zverev. Carefully evaluate the results achieved in the MIET, Sergey expressed surprise that such a large number of complex R & D is carried out by a small team, and offered to convert the laboratory in KB for the development of specialized computer technology. Soon it signed a corresponding order. The resulting CB MIET new status will significantly increase the volume and quality of the work here, the largest of which is at the end of the 1970s. It was the creation of a digital computer system "Tunguska".

As recalled VA Barkhotkin, *"interaction with our laboratory CPP began in 1972 with what he saw and appreciated Shipunov us as capable professionals who can significantly raise the intellectual level of equipment for the" Tunguska ". Jobs Arkady Georgievich was very constructive, which was stimulated by the fact that he was a great scientist, engineer, production worker. Thanks to his ability to understand any technical issues created the impression that he knows in any complex every every nut or chip resistor. Unlike many of our customers, he repeatedly came to our institute, and communicate not only with the leadership, but also passed on laboratories, talked with the staff, listening and literally catch their thoughts. From such a person was not sorry to hear and harsh criticism. Such attitudes have a great responsibility, and we remain faithful to Arkady Georgievich even in those years when the work on the "Tunguska" frozen. Despite the fact that the proposals we have had quite a few, "Tunguska" we do not forget and of*

*requests coming from the CBI on the implementation of a work is not refused. In the future, Arkady G. times, talking with us, saying that we most reliable friends. We have always tried to justify this assessment.*

*I remember how one day in one of the offices of the PCU to our claim on a problem with the accuracy of firing a gun. We quickly learned at this problem and went to Tula. Arrange in a cabinet Shipunova their calculations, tables and graphs. He was already prepared by their subordinates to ensure that we are in this situation is extreme, and began to carefully study our materials. I watched, and he thought for a long time, and fully imbued with our point of view. Following this, he glowered at his experts and said, "Well, you brought me! Then you will understand. " He looked at us with great approval. "*

*According to the memoirs AG Shipunova, "When in the early stages of work on the" Tunguska "we regularly listened to the arguments of our opponents, we try to not only meet him, but Mota to your mustache. Indeed, in their statements there was a lot of value based on their experience, the acquisition of which is for us one of the main tasks. Eventually, when mining at the site "Tunguska", we started to deal with such issues, of which we had never had any idea. And we wanted to give them immediate and correct answers, explaining the reasons for the event of failure. Often it was required to do in the absence of data telemetry data of the on-board equipment.*

*The same calculations that we performed after each test, it was a lot of trigonometry, and because computers did not exist, had to look for answers in the tables on the calculations took a very long time. It is difficult at the "Tunguska" was working out of the software tools industry. It was not in the company and become extremely necessary in the performance of such a large complex works of ground tests. Therefore, fine-tuning "Tunguska" comes out on prototypes combat vehicle at the site.*

*This is often performed in a manner significantly behind the times. So when we arrived at our site at the site, on the state of work can be easily judged by the situation in the combat vehicle Krichevsky, the lower half of which protrudes out of the hatch. On the one hand, it was a heroic behavior, people gave all the time and energy, and on the other - it was very clear that much work is impossible. And we have is learning. Sometimes we have helped previous experience and intuition, sometimes - good luck. But it happened that did not help anything, even referrals to major research organizations. "*

*The final launch weight designed for the "Tunguska" missiles (which received the designation 9M311) was 42 kg, and with transport and launch container - 57 kg. Missile length equal to 2562 mm. Both her step - starting with a diameter of 152 mm, and the march, with a diameter of 76 mm, made on a "duck" - equipped with fins, opens with springs after the rocket out of the container.*



Designed for single-mode rocket engine, which is the average time was 2.6 seconds, clocked a rocket to a top speed of 900 m / s. After his separation stage march weight 18.5 kg continued flying in a ballistic mode with minimal loss in speed. Moreover, its average flight speed was 600 m / s, and disposable overload reached 18 units. This allowed us to hit the high-speed, flying at speeds of up to 500 m / s, and intense maneuvering with congestion to 5-7 units of the target as a collision, and the Dogon courses at a range of up to 8 km.



*The managers and leading specialists of the PCU - the creators of the IRC "Tunguska".*

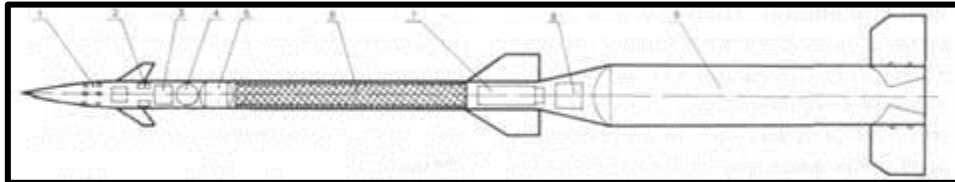
Combat gear, designed for the cruise missile stage, included a 9-kg warhead, fuse contact and non-contact sensor. Proximity sensor A 0.8 kg consisted of four semiconductor lasers with an optical system to form eight-beam antenna pattern perpendicular to the longitudinal axis of the missile. Laser signal reflected from the target, taken photodetectors. Range confident sensor response was 5 m, a reliable failure - 15 m.

The proximity sensor platoon radio signal for 1 km to the meeting with the aim of, and the undermining of warhead was carried out within a radius of 5 meters from the goal. In the case of a direct hit, the probability of which is around 60%, undermining the fuse pin was made.

The missile was made in the form of a large bay with extension rod striking elements. The main part of the striking elements of combat is the core, having a length of 0.6 m and a diameter of 4 mm. Arranged on the surface of the warhead, when they are undermining separated, forming a continuous ring with a diameter of about 5 m. The advantage of such submunitions are usually before application of a continuous cut and trim the joists objective that led to destruction of its structure, i.e. to defeat in an "instant destruction of targets in the air." In order to improve the efficiency of defeats the purpose of a missile also had a fragmentation jacket

generator shrapnel field element cubical mass 2-3 In aggregate warhead provided a cutting action on the elements of the airframe goals and incendiary effect on the elements of its fuel system. For small slips (up to 1.5 m) and provides both high-explosive impact on the target.

In addition to military equipment, as part of the cruise stage of the rocket were the antenna-waveguide system, electronic control unit, the coordinator gyro unit steering gear, tracer and power supply.



*Layout SAM IRC "Tunguska":*

1 - proximity fuses; 2 - Tie machine; 3 - the block of autopilot; 4 - giroinstruments autopilot; 5 - power supply; 6 - warhead; 7 - radio equipment; 8 - stage separation device; 9 - SRM.



*Fighting vehicle IRC "Tunguska".*

To a large extent the high performance characteristics missiles obtained due to its high propulsion equipment. No other than solid fuel, it could not be. Especially in the 1970s. for this class of propulsion systems was proposed and implemented a number of advanced technical and technological solutions that will significantly improve their energy, physical, mechanical and operational characteristics, as well as reduce the cost of development and production. Designed for 9M311 engine fully incorporates these achievements.



AG Shipunov recalled: *"High characteristics rocket propulsion were largely obtained thanks to our leading designer, chief technologist Vladimir Dmitrievich Kalmykov. Even in the earliest stages of work, he offered to make the motor housing made of composite materials, a method of winding. Although I was a big supporter of this design, however, he did not insist on its unconditional acceptance. On the contrary, I tried very hard to target businesses in search engine specialists in different directions, they sought from objective assessments of these options. After all, this unique design propulsion systems for rockets caliber of our not yet met neither we, nor abroad. But Kalmykov some inner instinct imbued with the reality of this design and implementation at a meeting confidently said: "Everything will be in the best form."*

*When we proposed a rocket start successfully fly us all kinds of meetings and councils began to persistently ask the question of what separates the engine can someone get. Of course, we have already been treated without irony the old, and we became more experienced fighters. So the first time on this question, we answered their set: "And what to do defeats the purpose? And it shot down a missile? It's the eternal question, which came from the anti-aircraft artillery - where fragments of shells are falling? "Gradually, however, this concern and passed on to our customers, making us do a lot of work associated with the study of processes fall accelerators*

*In reality, it was found that after the separation of the engine from the cruise stage of the rocket very quickly braked. And falling on the ground, it becomes practically safe for the people in the cab. And when you consider that today in combat conditions, people rarely appear on the battlefield without adequate protection, and the possibility of them falling on the accelerator becomes purely speculative. "*

Much more serious in its importance was the question of the impact of the plume of hot gases to work guidance system. To eliminate this phenomenon, it was decided to apply the soft start portion of the arcuate path of the output of the rocket. Conclusion missiles at the target line of sight began to 2-3 before the meeting ended with a goal and in the immediate vicinity. Thus, almost the entire flight path missiles came to her deviation from the line of sight of the target, which eliminates the impact on job finder trail of smoke missiles, as well as reduce the likelihood of their capture IR-traps, fire back end.

As noted by AG Shipunov, *"in general, the problems associated with optical finder, who accompanied the rocket at the launch site, were the most significant among the issues we encountered in the experimental development "Tunguska". Even during the first launch of the rocket plume revealed the instability of the glow engine, which in the area dispersal played for us the role of the tracer. Initially, the torch was bright, then faded, and then recovered its brightness. Direction Finder at this chart of the engine functioned very poorly, and this circumstance, we were extremely disappointed. In discussing this problem*

*arose the proposal to install on the starting stage of the rocket tracer. But after a couple of days it became clear that we need mass tracer could amount to almost 2 kg. Such an appendage to the rocket almost deprived of its ability to accelerate to the required speed and fly at the required distance. Moreover, this could be a false tracer purpose after the separation of the engine from the cruise stage of the rocket. So it was the wrong way to go and we went to the Perm NIIPM to developers of solid charge for our engine. "*

Joint activities of the PCU with the Perm Research Institute of polymer materials is always held on the highest level. This company was founded in 1950 on the basis of a small research laboratory of the plant. CM. Kirova, one of the major manufacturers of solid fuels in the country. During the Great Patriotic War here it was made up to 40% of the charges for the legendary "Katyusha". After creating NIIPM here we began serious work on improving manufacturing processes charges were designed and developed a composite solid propellant. It is these fuel eventually made power base for the majority of the samples produced in the country of missile technology. Along with the development of new fuels in NIIPM shaped and unique experimental base, which enabled to provide checks and fuels produced on the basis of their charges in the toughest conditions of future exploitation.

*As recalled AG Shipunov, "headed NIIPM for decades Leonid Kozlov was natural to Russian good girl. Came to him with their problems, we have discussed with him a lot of questions. We talked about the booking of the fuel charge, about modern methods of its application. And then we moved on to worry about the issue of the level of the flame glow engine. We ask him how can we be? Leonid thought for a moment, and without plunging us into the maze of chemical interaction of the combustion products, proposed a solution - be shortened by a few millimeters of the supersonic nozzle. I could not resist and asked him what it will change? He said in reply, so we increase the temperature of the gas at the outlet of the nozzle, and thus increase the brightness of the flame. Honestly, I took it with a grain of salt simple sentences. Internally, I was ready for what he offers us to do specification of fuel formulation, consider the use of new technologies, enter into an agreement. But it turned out that the solution we needed only a few minutes of conversation. But as soon as we returned to the plant, we immediately cut off from the nozzle proposed Kozlov millimeters. And everything went as he had predicted, and we have since forgotten about this issue. "*



*LN Kozlov.*



*BV Novoselov.*

Fruitful PCU has established creative communications with Kovrov Institute "Signal", which became the parent company for the guidance system, stabilization of the line shot and the optical sight, the navigation equipment.

*According to his chief complex Institute "Signal" to Boris Novoselov, "Arkady G. Shipunov probably one of the few general designers who understand the importance and difficulty of creating highly dynamic precision drives. He gave this issue the most serious attention. Yves each developing guidance and stabilization under its influence had to use creative solutions. Thus, the drives "Tunguska" has been used a sliding mode elektrogidroprivodov. No wonder, when the question of copyright collective applicants Lenin Prize for his work on "Tunguska", then it was included on the "Signal" Chief Designer Ivan Pavlovich drive Zikov. And at the meetings of the Council of Chief Designers on all developments Arkady G. has always provided to the developers drive guidance and stabilization, and sometimes even promoted the development of a "signal" Drives. "*

In general, cooperation development "Tunguska" was very reliable. In addition to those companies that have already been mentioned, in the creation of the new complex was attended by the Ulyanovsk Mechanical Plant (parent company of radiopribornomu complex, Chief Designer - Yuri Ivanov), the Leningrad Optical and Mechanical Association (for sighting and optical equipment), Kirovsky Zavod " Lighthouse "Izyum Instrument Making Plant (optical finder missiles), Minsk Tractor Works (by shestikatkovomu crawler GM-352, power supply system) ...

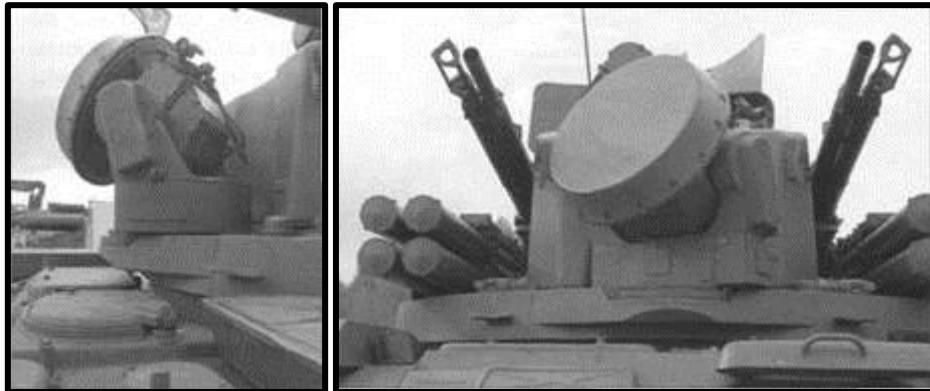


*Fighting vehicle IRC "Tunguska" in the stowed position.*

AG Shipunov recalled: *"I think we are very lucky that the developer of the chassis has been assigned the Minsk Tractor Plant. Chief Designer of special equipment factory was Boris Algin. It is known that armor is slow, conservative and inert. But Algin was a great leader-and on the chassis, which was developed for the "Tunguska", he managed to make a technological breakthrough in several directions. On this machine were performed hydromechanical transmission and hydropneumatic cushioning. Also introduced hydrostatic steering gear - almost tracked the car we had a car wheel. As a result, we got kvazistabilizirovannuyu platform that allowed us to work on the go and reach high speeds on rough terrain when the engine power of all 710l.s. Of course, such a novelty brought with it considerable risks, but in Minsk managed to cope with this, although fine-tuning of the machine had to deal even at the stage of mass production. But, in the end, the required parameters are achieved.*

*At the same time some of the questions addressed in cooperation difficult. For example, for the manufacture of towers war machine was originally defined Gorky plant. But, as it turns out, we are not engaged in the manufacture of armor designs. And we were advised to contact the factory in Podolsk. Before us loomed the prospect of a considerable loss of time, and I had to go to non-traditional way. While the Podolsk district committee secretary was my classmate Basil Serafimovich Pestov. And I went to him and explained his problem, and he met the full understanding. Soon he sincerely talked to the plant manager Leonid Samuilovich Chubarov. And then I came to him to the plant from the working group. We met some very friendly attitude, factory specialists praised the tower designed by us for the design of technology, in terms of reliability. As a result, the foundation was laid for the friendship and cooperation with another plant. In*

*general, like meeting new enterprises is not always accompanied by further works, but here everything worked as it should. "*



*Antenna SCC.*

Despite the highest saturation of equipment and use of useful volume comparable to the aircraft, designed for the "Tunguska" combat vehicle 2S6 it turned out relatively easy and graceful. With full ammunition and fuel its weight is about 34 tons. It had a high throughput, flexibility, and smoothness, providing the possibility of conducting radar reconnaissance and destruction of air targets on the move.

Inside the tower housed a crew consisting of commander and two operators. The driver was in the front compartment. Fighting machine was powerful enough to book, to effectively protect the crew and equipment from bullets and shrapnel.

The functioning of the combat vehicle 2S6 usually would be carried out independently. This does not prevent her work and in the management of air defense of the Ground Forces. In standalone mode provides: search target (a circular - with station detection and targeting (SOC), a sector - with the help of the station maintenance purposes (SCC) or optical sight); recognition of her nationality with the built 1RL138 interrogator; target tracking by angular coordinates (auto - with the help of CSS, semi - using optical sight 1A29M so-called inertia - using digital computing system (CMC) under the assumption that the target moves in a straight line at a constant speed) and distance (automatic or manual - with the use of SCC, automatic - using SOC, inertia, as well as fixed rate, determined by the type of commander visually selected for fire purposes).

Fighting vehicle equipped with a system power supply, navigation, external and internal communication, ventilation and microclimate, observation equipment, Nuclear,, anti-gas and antibacterial protection, fire-fighting equipment.

On the military machine was installed tower, which is a horizontal rotating actuator guidance. It housed two radar - Station detection, identification and target designation and tracking station, optical sight, missile launchers, two 30mm guns, drive vertical guidance.

Radar-instrumental complex included a radar, a digital computing system and the system of measuring angular kachek.



*Anti-aircraft machine gun and missiles in TPK.*

The structure consisted of a radar system radar detection and targeting systems, ground radar interrogator radar target tracking and transmission on board the rocket flight control commands.

SOC 1RL144M represented coherently pulsed radar Omnidirection dm range. High frequency stability of the transmitter, configured as a master oscillator and amplifier chain, the use of a filter circuit moving target to provide high suppression of clutter (30-40 dB), which allows detection of targets against the background of intense reflections from the underlying surface and passive interference. Unambiguous definition of the range and radial velocity achieved by selecting frequency values and the pulse repetition frequency, which allowed to implement target tracking in range and azimuth, automatic target designation station tracking and delivery of the current range in the digital computer system as a backup option in the formulation opponent intensive interference in the range of operation tracking station. To ensure the functioning of the move was used electromechanical antenna stabilization system using a system of measurement and kachek course self-propelled.



*Antenna SOC in firing position.*

When the pulse power 7-10 kW transmitter, the receiver sensitivity of the order of  $2 \times 10^{-14}$  watts, the width of the antenna pattern in azimuth of  $5^\circ$  and  $15^\circ$  elevation station with a probability of 0.9 detects air targets with EOC fighter at altitudes of 0,025 doses, 5km, at a distance of 16-19km. At the same time the resolution of the station and the mean square error in determining the coordinates were, respectively, 500 m and 20 m in range,  $5-6^\circ$  C and D in azimuth,  $15^\circ$  and  $5^\circ$  in elevation .

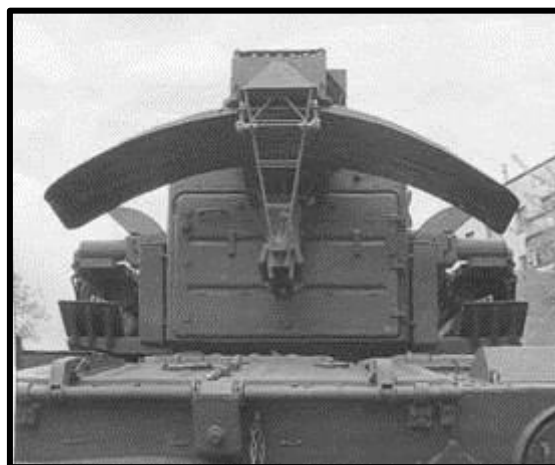
SSC was a coherent pulse radar-cm range with dual-channel support system, the angular coordinates of filter circuits with moving target channels avtodalnomera and corner support. Coefficient of clutter suppression and clutter was 20-25 dB.

The station moves to the auto tracking and targeting modes search targets within the sector corresponding to  $120^\circ$  in azimuth and  $0-15^\circ$  in elevation. When the pulse transmitter power of 150 kW, the receiver sensitivity  $3 \times 10^{-13}$  W, the width of the antenna pattern  $2^\circ$  (azimuth and elevation) station with a probability of 0.9

provided the transition to auto tracking target in three dimensions (with image intensifier equal fighter) flying 0,025-1,0 km at altitudes of 10-13 km with a range of SOC at the target designation and 7.5-8.0 km at independent sector search target. Resolution stations and standard errors tracking were, respectively, not more than 75 m and 2 m in range and 2 ° and 2 PDE the angular coordinates.

Both stations have successfully detect and track low-flying and hovering helicopters. Detection range of the helicopter, flying at an altitude of 15 meters at a speed of 50 m / s, with a probability of 0.5 was 16-17 km range of the transition to auto tracking - 11-16 km. Hovering helicopter SOC detected by the Doppler frequency shift of the rotating screw and took the auto tracking in three dimensions SCC.

Stations "Tunguska" had the means of protection against jamming, and also has the ability to target tracking in noise due to the combination of radar and optical means fighting vehicle. Shock protection anti-radar missiles could be provided by the above combinations, the operating frequency spacing of stations regulated by time or simultaneous operation at close frequencies separated from each other by a distance greater than 200 m several military vehicles as part of the battery.



*SOC antenna in the stowed position.*





Installed on a combat vehicle digital computer system 1A26M intended to solve the problems of arms control and stabilization, optical sight and radar, flight control commands generation missiles during combat operation, as well as to validate the operation of systems in the control mode.

Reticle consisting of sighting and optical equipment, guidance and stabilization of the optical sight, equipment selection Coordinate finder IR missiles, designed to detect and track targets at the optical channel and missiles, and the issue of the definition of their coordinates digital computing system to solve the problems of fire control and develop rocket flight control commands.

The combination of different methods of tracking the angular coordinates and range means fighting machine provides several modes of operation:

- the three target coordinates received from the radar system;
- for the target range received from the radar system, and its angular coordinates obtained from optical sight;
- inertial target tracking in three dimensions obtained from the computer system;
- the angular coordinates received from the optical sight, and set the target speed commander.

When shooting moving targets on land used semi-automatic mode or manual pointing weapons at the point of pre-emption on the remote grid sight. After the search, detection and identification of target tracking station passed at its auto tracking on all coordinates.

When firing from guns CRV solves the problem with a view to meeting the shell and determined the affected area according to the data supplied from the output

shaft of the antenna SCC, from the block selection signals errors on the angular coordinates and range finder, and the system of measuring angles and course kachek combat vehicle. In setting opponent intense noise SCC channel ranging skips manual target tracking in range and in case of his inability - on target tracking in range of the SOC or its inertial tracking. In setting opponent intense noise in angular SCC channels target tracking in azimuth and elevation performed with an optical sight, and in the absence of visibility - inertia (from CMC).

When conducting fire missiles used target tracking by angular coordinates with an optical sight. After starting the rocket fell into the field of view of the optical finder equipment selection coordinate missiles. In light signal from the tracer was determined by the deviation of the missile with respect to the line of sight targets (in angular coordinates), parameters which enter the Central Military Commission. In turn, the CMC generates control commands missile enters the encoder for encoding pulse premise that through the transmitter tracking station transmitted to the missile. Movement missiles almost the entire trajectory happened with the deviation from the line of sight of the target of 1.5 PDE to reduce the likelihood of getting into the field of view finder of shot purpose thermal noise. Withdrawal missiles at the target line of sight began 2-3 before meeting with her and ended up near her. When approaching the target at a distance of about 1 km to the rocket passed command arming proximity fuze. After the expiration of the corresponding span this distance missile, combat vehicle is automatically translated into a willingness to launch next-Zour.

The complex jamming environment, in the absence of information about the CMC target range from the radar combat vehicle, apply additional missile guidance mode. This rocket withdraw to the line of sight immediately after the start, proximity fuses cocked by 3.2 seconds after the start, and bring war machine in readiness for the next launch missiles performed after the time a missile at maximum range.

*As recalled AG Shipunov, "gradually the main problems associated with working" Tunguska "have come down to us in working off the radar detection and tracking. Quite unexpectedly in front of us there was a pretty artsy question as soon as the the radar, began swinging the whole machine, and therefore, degrade the performance of the radar, it began to grow error. We conducted a series of experiments and gave to the Ulyanovsk plant elemental recommendation - balance the dish! But local experts took this with a grain of salt. They explained swinging machine large wind load. Argue with them, we were not just asked to conduct the test in a full calm. And quickly fell into place - the car still rocked. Shortly balanced antenna, and the problem has been removed.*

*Of course, our forward movement with working "Tunguska" occurred not as fast as we would have liked. Terms began slowly swimming, and in September 1980 I was summoned by the chief of Grau PN Kuleshov. He continued to look very carefully*

*at our work, helping all available to him means. Now, he told me that it was time to bring "Tunguska" on state tests. I thought it was premature to do so, it has not been solved all the problems. But veteran Pavel Nikolayevich did not get to the heart of these problems and told me:*

*- shoot shoot? The cycle worked out? It is necessary to show, otherwise you may have trouble. I promise that the approach will be the most favorable.*

*And he kept his promise. "*

In late September 1980 at the Donguz test site began public testing IRC "Tunguska". Commission on these tests led YP Belyakov, who managed to ensure its rapid and efficient operation. The commission also includes AG Shipunov, NP Bryzgalov, PS Caumont, VK Korostiev, VM Kuznetsov, AD Rusyanov, IP Zykov, EV Grigoriev, VV Town Hall, AD Guryanov, IL Maksimov, MD Mezentsev and other representatives of the Ministry of Defence and industry.

December 31, 1981 state tests were completed, and September 8, 1982 the complex 2K22 "Tunguska" was adopted, and soon went to the troops.

Organizational four combat vehicles 2S6 usually reduced in the anti-aircraft missile and artillery platoon of antiaircraft rocket-artillery battery consisting of a platoon SAM "Strela-10SV" and platoon IRC "Tunguska". The battery was part of the anti-aircraft battalion of motorized infantry (tank) regiment. As the battery commander's point control unit was used PU-12M, which was associated with the command post commander of the anti-aircraft division - Head of Air Defence Regiment. In turn, as the regiment command post served as a control point air defenses Regiment "Gadfly-MCB" (mobile unit exploration and management PPRU-1) or a modernized version of the "Building" (PPRU-1M).



Later armored 2S6 have been interfaced with the unified battery commanding point 9S737 "Rankings". When pairing "Tunguska" with PU-12M and MC commands with the latter on the armored 2S6 transmit voice via radio staff, and when paired with 9S737 - using codified generated equipment data. In managing the "Tunguska" from the battery commander's item analysis air situation and the choice of targets to shoot at each complex we had to be made on this point. On combat vehicles should transmit orders and targeting, and complexes with the battery commander's point - data on the status and results of the Battle of the complex.

Work armored 2S6 is provided by the transport and loading vehicles 2F77M (on KAMAZ-43101) with two rounds of ammunition and eight rockets, machine repair and maintenance 2F55-1 (chassis Ural-43203 with trailer) and 1R10-1M (chassis Ural-43203, for electronic equipment), machinery maintenance 2V110-1 (chassis Ural-43203. on the artillery armament), automated control and test mobile stations 9V921 (on the GAZ-66), workshops and service logistics-ATG-M1 (in ZIL-131).

For the creation of "Tunguska" in 1984 he was awarded the title Hero of Socialist Labor V. D. D. were awarded the Order of Lenin AG Shipunov and AA Popovkin.

In 1986, for his work on "Tunguska" were awarded the Lenin Prize AD Rusyanov, AG Golovin, PS Caumont, VM Kuznetsov.

In 1988, for the development, testing, development of "Tunguska" in the serial production of the State Prize of the USSR were awarded IP Zykov, VA Korobkin, NP Bryzgalov, LB Bittman, VG Grandchildren, VK Korostiev.



*Participants work on the complex "Tunguska" after the ceremony: IP Zykov, VA Korobkin, VM Kuznetsov, AG Golovin, PS Caumont, AD Rusyanov.*



*So were foreign experts complex "Tunguska" in the mid-1980s.*

By the end of 1980. IRC "Tunguska" abroad had different designations - ZSU-30-2, ZSU-X, SPAAG M-1986 (at the time of his first identification ). The final form of the complex Harden designation SA-19 (in the terminology of the United States) and Grissom ( NATO terminology).

The adoption of "Tunguska" for service was truly outstanding event. In the United States and Western Europe was still only formed the preconditions for the start of work on such mobile short-range air defense systems.

So, in 1975, the leadership of the US Army decided to use for the same purpose complex Franco-German "Roland". In those years, the SAM system was considered the most advantageous to the French "Krotalem" and the English "Rapier". However, spending about 300 million. USD., In 1981, the Americans refused to continue this work: as explained, because of the difficulties encountered in reaching an appropriate set of American standards and unacceptably high cost. However, the final rejection of the idea was not followed. In 1985 the command of the US Army announced the start of work on a comprehensive program FAADS (Forward Area Air Defense System), the estimated cost of which is assumed to be 11.5 bln. Dollars. Its implementation was dramatically affect the ability of the land forces to meet the challenges of struggle low-flying targets of different types, primarily with combat helicopters, and in some cases - and the defeat of armored vehicles.

One element of this program was the creation of a combined missile and artillery complex LOS-F (Line-Of-Sight-Forward), intended to hit targets in the line of sight at a range of 6 to 8 km and Defense departments are in direct combat contact with the enemy and anti-aircraft missile complex LOS-R (Line-Of-Sight-Rear) to destroy air targets in the line of sight and defense facilities in the rear area of the division.

Announcing the program FAADS, Americans considered the most sensible to involve her in the most well-known companies-developers of air defense systems from different countries. The final selection of the winner was supposed to do after the comparative tests. And proposals did not take long. Soon, the US test site in White Sands has several air defense systems, equipped with as the missile and gun armament: American-French "Liberty" with the VT-1 missile (firms "Wout" and "Thomson-CSF"), the US-Swiss ADATS (firms, "Martin Marietta" and "Oerlikon"), a self-propelled version of the English SAM "rapier" (Consortium "Aerospace Dofens System"), "Paladin", created on the basis of complexes "Roland-2" and "Roland-3" (Consortium "Western Alliance Air Defence").

The main challenge for each of the missile and artillery systems were to be made to them ten launches of unmanned aircraft and helicopters. These launches have drawn a line in the competition, the winner of which was the ADATS, hit eight targets.

However, the final stage of preparation na na contract worth 1.7 bln. USD., Which provides for the production of the first 166 systems (a total of 566 and planned to produce about ten thousand rockets), because of the change in the international situation, and a number of identified deficiencies ADATS The situation has changed dramatically for the winners. Ultimately, large-scale orders for ADATS never came.

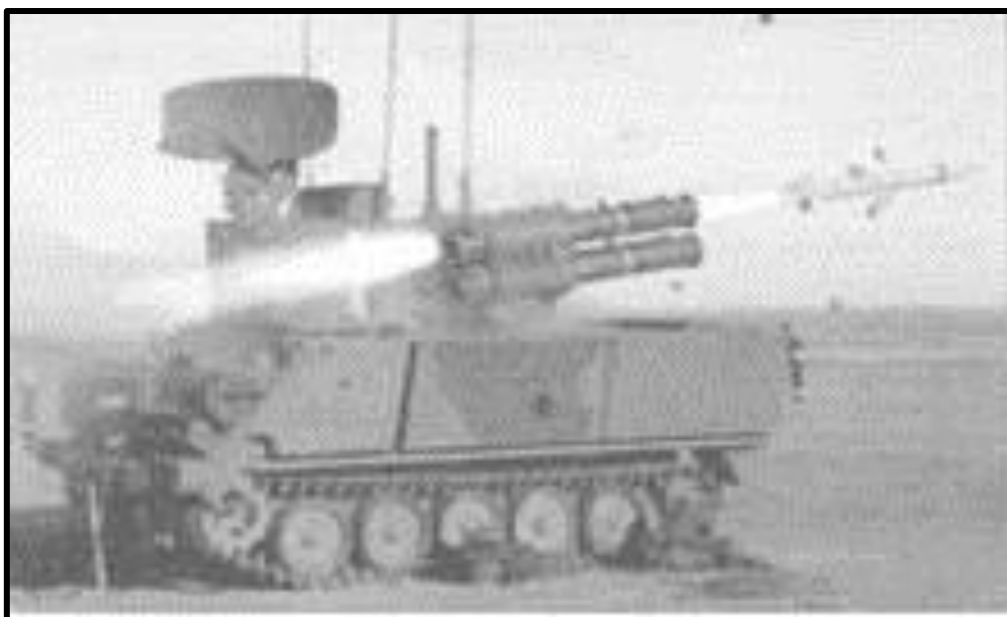
As a result, until the end of the XX century counterparts "Tunguska" and did not appear! And its creators, meanwhile continued to improve his creation. From August to October 1990, the Emba polygon (Head landfill - VR Unuchko) under the leadership of the commission headed by AJBelotserkovskim (the commission also included A .M. Davydov, Yu Tokarenko, NN Zhevlakov, AE Vasiliev, AP Grishin VA Cooks, MI Yurutsa, AS . Glinka and others) have been tested complex **"Tunguska-M" (2K22M)**. In the same year the complex was adopted by the Soviet Army.

The bulk of improvements this version of "Tunguska" has been associated with the addition of a new radio and a receiver for communication with the battery commanding point "Rankings" (PU-12M) and command post PPRU-1M (PPRU-1) as well as the replacement of the gas turbine engine power supply unit to the new complex, with half the increase of operating life - up to 600 hours.

Start of work on the further modernization of the "Tunguska" coincided with operations in the Gulf, during which the new strategy has been demonstrated on the battlefield. It involves the application at the beginning of combat operations massive air strike aircraft operating outside the affected areas of air defense, based on small unmanned aircraft for various purposes. This made it possible to identify the location of radar reconnaissance, and air defense weapon systems for their further destruction. As a result, air defense troops and objects destroyed in a short time, after that will be in effect manned aircraft.

Thus, in the early 1990s. It acquired a special urgency for the fight with a lot of concurrent pinpoint aerial targets.

As a result, in the further modernization of the "Tunguska" in the war machine was introduced automated equipment for receiving and processing the data of external target designation from the command post type PPRU (9S80). It is possible to organize the automatic allocation objectives between combat vehicles and greatly enhance combat efficiency of the battery ZSU on reflection massive raid. Made at the same time upgrading the digital computing system "Tunguska" on the basis of a new calculator allowed to extend its functionality in the solution of combat and control tasks, improve the accuracy of their solutions.



*Start SAM missile ADATS.*

At the same time the main limitation in increasing the efficiency of the complex anti-small-sized purposes was associated with the use of missiles as part of a non-contact sensor purpose built laser-based. This sensor had good performance, high reliability, has worked well in the specified temperature range is guaranteed to breakdowns in intercepting large size target, but a small target could "slip" between the laser beams.

Another disadvantage of "Tunguska" lay in a semi-way tracking the gunner through a telescopic sight. In the military machine it was inherently automatic tracking radar tracking when shooting guns. Artillery fire did not require the highest precision guidance, errors were minor to the radar scattering clouds of shells near the goal. In turn, the rocket had to pass close to the purpose of the air at a distance of no more than 5 m, and mounted on the "Tunguska" radar gave 8km fault of their own, which was twice the required parameters. Therefore, only the use of optics allowed to withdraw the missile at the target with an accuracy of 2-3 m, but this required highly skilled operators, who were supposed to train their skills constantly.

In 1992, commissioned by the PCU Grau Defense Ministry started work titled "Unloading of the operator." In the course of its execution was introduced discharge pattern will greatly facilitate the work of the gunner when accompanied by an XY mobile air target optical sight. It also provided an opportunity to realize the idea of using a tracking station for the automatic tracking of air object when firing a missile. At the same time remaining pointing error the operator can select using the manual manipulator.

The structure of the equipment fighting vehicle were introduced: the reception equipment and automated targeting implementation of the battery commander



points; IR-direction finder missiles - missiles coordinate generation equipment; a new computer that has great speed and memory; modernized system of measuring angles kachek.

Carried out at the site field tests yielded good results: support has been enhanced accuracy and reduced dependence of the efficiency of combat employment of missile using the optical channel of the level of professional training of the gunner.

Along with this, the PCU and perfected itself rocket, designated **9M311-M1**. Its march step instead of the tracer in the rear, is a source of the signal to the sensor coordinate missile was equipped with continuous and pulsed light source - lamp-headlamp. Undergone revision and instruments missiles: it was increased noise immunity for the purposes of the shelling, using optical interference, non-contact laser sensor was replaced by radar, omni-directional antenna.

All this has increased the affected area of the complex up to 10 km, improve immunity optical line missile control is guaranteed to hit small targets such as cruise missiles.

From the memoirs AG Shipunova: *"In general, the situation in our work to improve the "Tunguska" has been favorable. All participants worked on a cooperative task. Of course, to some extent, we continue to compete with the established by the time the "Tor", although our system was not all-weather due to the fact that in the early stages did not find appropriate solutions to create these tools for automatic tracking. But by the time of the option "Tunguska-M1" solutions have been found, and it turned out very well - in the demonstration test has been received a direct hit in such a difficult target, as the E-95. However, it was in the 1990s, when it came other times. "Tunguska-M1" has been tested, but it did not take long for service. The formal reason was that put forward in this decade of the new requirements for the complex provides for the domestic production base. Therefore, instead of the GM-352 manufactured in Belarus "Tunguska-M1" gained the chassis GM-5975 Mytishchi Production Association "Metrovagonmash." Special objection was not there, but our fighting vehicle initially lost some of its valuable qualities, including hydropneumatic suspension. I'm all the forces opposed to such an approach, spoke at the meetings, saying that it would sharply reduce accuracy, especially in the movement. Little by little, I began to listen, and eventually we were able to joint efforts to bring the car to the required level. "*

The final upgraded **"Tunguska-M1"** was adopted by the September 2, 2003

This version of the complex provides anti-aircraft guns firing away, short stops and on the move at any time and any weather conditions, and missiles with space - in terms of visibility.

Besides fighting tools of the IRC "Tunguska-M1" includes funds for maintenance and repair, and training aids. The structure of the maintenance and repair include: transport and loading vehicle 2F77M; machine repair and maintenance 1R10-1M1; Machine maintenance 2V110-1; machine repair and maintenance 2F55-1M1; machine (workshop servicing) MTO-AG3-M1.

### **The main characteristics of the different options IRC "Tunguska"**

Option	"Tunguska"	"Tunguska-M"	"Tunguska-M1"
SOC detection range, km	18	18	18
Range support SSC, km	13	13	16
The maximum speed of the targeted goals, m / s	500	500	500
The affected area for the cannon armament, km:			
Height	0-3,0	0-3,0	0-3,0
in range	0.2-4	0.2-4	0.2-4
parameter	2	2	2
The affected area for the missile, km:			
Height	0,015-3,5	0,015-3,5	0,015-3,5
in range	2,5-8	2,5-8	2,5-10
parameter	4	4	
The reaction time, with	-	-	6-8
Ammunition:			
missiles	8	8	8
30mm shots	1936	1936	1904
Speed, km / h:	65	65	65
highway			
on a dirt road	40	40	40
on the road	15	15	15

Transport and loading vehicle is designed to transport 2F77M 32 boxes with bullets and eight rockets, as well as for equipment or demilitarization cartridge tapes.

Machinery maintenance and repair ensure conduct routine maintenance and maintenance of radar and digital computer equipment, electrical equipment, crawler chassis and car recovery efficiency of mechanical assemblies, transportation, storage group sets of spare parts and training facilities.

To test missiles at the bases of storage used automated control and test mobile station 9V921M.

The structure of training facilities include: training device for the commander ZSU and radar operator 1RL912M; Autonomous gunner simulator 9F810M optical sight; classroom study material of the ZSU and methods of operation.

Training funds held in the complex provide in conjunction with the work on the possibility of a real air targets calculations instilling solid skills in combat actions in difficult conditions.

Organizational IRC "Tunguska-M1" usually forms antiaircraft artillery battery, which may be part of an anti-aircraft battalion of motorized infantry and tank regiment, brigade, division. As part of the battery usually have separation of management and three anti-aircraft platoon.

Anti-aircraft platoon is the basic tactical-fired unit, the optimal composition of which suggests the existence of two fighting two freight loading vehicles. Platoon of this composition is capable to fight and perform combat missions as part of the battery or on their own.

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*Dear readers!*

*The "against» №4 / 2011 article on IRC "Tunguska" was a typo. On p. Yves 1st column in the 2nd paragraph, should read: "The machine can work at angles of elevation from -9 to +85 ° ... "(corrected in the text, was printed - 8 °, approx. Air Force)*

***IRC "Tunguska"***



*Transport and loading vehicle 2F77M.*



*Fighting vehicle IRC 2K22M1 "Tunguska-M1" of JSC "Ulyanovsk Mechanical Plant", presented at the exhibition REA 2009.*